sounder, more self reliant and more efficient.

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ON THE PHYSIOLOGICAL EFFECTS OF MODERATE MUSCULAR ACTIVITY AND OF STRAIN[1]

Practical efforts, both in Europe and America, to solve the problem of physical training in schools and colleges have proceeded along two different lines, which are roughly typified in Europe by the English system, on the one hand, and the Swedish and German systems, on the other. In the former, athletic efforts may be said to play a predominant rôle; in the latter, they are strictly subordinated in the endeavor to reach the masses. Similarly, the practise in America differs considerably. In some colleges the great stress is laid upon athletics; in others athletic activities are entirely separate from instruction in physical training for the student body as a whole. But these are the extremes, for in the majority of cases the organization of the work combines, or seeks to combine, both. Perhaps it will be conducive to clearer thinking if we define at the outset the difference between the two extremes.

In those cases where athletics are under separate organization and control, it is the aim of the department of physical training to secure for each individual student the proper basis of health for his work in school or college and also to educate him in the truest sense of that word for the proper hygienic conduct of his subsequent life. Physical training is not regarded as an end in itself, but as an essential means toward the equipment of the individual for the work in which he may engage. The effort is, furthermore, made to do this economically as regards both time and effort.

The athletic ideal is entirely different. It does constitute at the time an end in itself; its primary purpose is not the cultivation of health, but of excelling some one else. It brings into play the elements of competition and championship. The athletic team of a school or college represents the best which the institution can do in that line of effort. Sacrifices of time, of convenience, and, generally, to some extent at least, of scholarship, are regarded as proper, if needed to secure the immediate end in view. Physical risks must be taken if necessary, risks which may end in permanent injury, and even in death, in order that one's college shall prove itself superior to some other college.

There are thus, these two ideals which come into practical work of physical training. It is of course not necessary that we adopt one to the exclusion of the other; but these ideals profoundly influence the practical measures adopted, and it is essential that we approach the solution of our problem from the right point of view. It should be added that, in giving each its due weight, other considerations than the strictly hygienic must enter into our decision. First, there is the question whether a given plan of action reaches the masses and is effective with them from the standpoint of physical training; and there is also the question whether we do not need to cultivate those moral qualities of group loyalty, of subordination of self to the interest of the whole, and of the willingness to make the supreme effort for a common cause, which is perhaps the very soul of modern school and college athletics. These are questions on which obviously the physiologist has not the last word,

[1] An address delivered in a symposium on "The Regulation of Physical Instruction in Schools and Colleges, from the Standpoint of Hygiene" before Section K (Physiology and Experimental Medicine) of the American Association for the Advancement of Science, Baltimore, December 20, 1908.

although he must have an important share in their answer.

Returning to the strictly hygienic side of the question, I am simply trying to get clear in your minds the fact that there are these two ideals and that one of them involves the necessity of training for and, at times, the making of a supreme physical effort on the part of the contestant. The other does not involve this element; on the contrary, perhaps it generally seeks to avoid it, thus leaving the individual free to concentrate his effort on some other object.

Now, whether we attempt or do not attempt to include these elements of moral education in our efforts at physical training, it is of first importance that we secure the hygienic ends and that our work be successful with the masses and not solely with those who finally engage in athletic contests. Not only this, but, viewing physical training as a part of education as a whole, it is even fair to demand of it that it do more than provide the physical capital for the work of life by securing the proper development of the body during the period of youth; it should also lay the foundation of correct habits; it should leave the student with the ability to enjoy those forms of physical activity which are possible amid the more serious concerns of adult life, and with a compelling belief in the necessity, even the obligation, of maintaining the physical man.

With this in mind, let us review rapidly the biological requirements of the human body for muscular activity as an essential factor in health. In this audience, it would be only to state a truism to say that the human frame is constructed for a life of muscular activity; that the fact that, until very recently, mankind has supported itself by physical rather than by mental exertion must have led to the survival of those with bodies adapted to physical exertion. So essential was it that this adaptation should be of a very high order, that we are not surprised to find that it went to the extent of producing a body not only capable of sustaining, but even of profiting by, physical exertion.

Assuming that this adaptation of the organism for muscular activity is the result of a hard process of natural selection, we should expect to find that the extent of the adaptation is determined by its survival value; that is to say, it would not be reasonable to expect adaptation of the race as a whole to degrees or forms of muscular exertion which formed no part of the daily life of the average man or woman, and we may assume to-day that the race as a whole is not likely to profit by forms of activity distinctly more strenuous than those to which it has been accustomed in the past.

"The muscular activity which thus formed part of the life of our ancestors may be described as generally moderate, though at times it was vigorous or hard; only exceptionally did it involve extreme endurance or great muscular strain. . . . Where work of this kind had to be done it was left to those who, by reason of exceptional strength, were especially fitted for it."[2] It would seem that it is to such work that the race, as a whole, is adapted and there is thus a strong *a priori* theoretical probability that it is by such work that it is most benefited. In using the term "moderate muscular activity" in this discussion, you will understand that I am referring to work of this kind. And it is sufficiently obvious that the training for beating a record, or for rowing, or football is something distinctly in excess of this.

Through what physiological channels

[2] Hough and Sedgwick, "The Human Mechanism," p. 312.

does this moderate muscular activity minister to the health of the body? We can not discuss this at any length here, and to do so would only be to repeat what has been explained over and over again. But we may mention the following as the principal hygienic effects.

1. Muscular activity affords training to the heart, so that it is not only equal to the emergencies of life, but is also able to withstand the fatigue of moderate prolonged exertion. No exercise can be enjoyed unless this fundamental condition is satisfied.

2. Muscular activity relieves vascular congestions in the internal organs by bringing larger quantities of blood to the skin. In doing this it improves the physiological condition of the skin, as well as that of deeper organs.

3. As a result of the deepened and frequently quickened respiration all lobes of the lungs are used and the apical lobes rendered less liable to the attacks of disease.

4. As a further result of the increased breathing movements, as well as of the pumping action of contracting muscles and movements at joints, the flow of lymph along the lymphatics is greatly favored, and this improves the environmental condition of all cells of the body.

5. Muscular activity also affords important training to the heat-regulating mechanism of the body.

6. Muscular activity exerts a favorable influence upon the digestive processes, promoting proper secretion and absorption and tending to prevent the unhealthful conditions leading to constipation.

7. Muscular activity is conducive to refreshing slumber. This is partly because of the maintenance of normal conditions in the body generally and probably, in part, because it is conducive to the healthful fatigue which facilitates the normal relaxation from nervous strain. Whatever may be the physiological explanation of the phenomenon, there can be no question of its existence and of its hygienic value to the nervous system.

It is not essential to our purpose that we make a complete list of these favorable physiological effects. Probably the above comprises the more important of them, and before leaving this part of our subject we may point out two things. First: these are all hygienic essentials and most, if not all, of them can be properly secured only by muscular activity. The training of the heart, the maintenance of deepened breathing without depriving the blood of its due charge of carbon dioxide, the favorable effect on the flow of lymph—for it is an old physiological observation that there is no lymph flow from the limbs when motionless—the favorable effects on digestive functions and on slumber, all of these can be secured in *no other way* than by muscular activity. This means that physical training is an essential in any properly planned course of education and that no school or college is justified on any ground whatsoever in failing to provide properly for this need of its students. Second: all these hygienic effects can be secured by what we have termed "moderate" exercise. Not one of them requires the effort involved in training for athletic events. This fact seems to me to justify a statement which I have made elsewhere to the effect that "the athletic ideal is not the hygienic ideal; it may not be unhygienic, but it is not required for purposes of health."

But athletic training and athletic contests may be at least desirable and possibly necessary for other than hygienic purposes; and so the question at once presents itself whether in using it for these purposes unjustifiable risks to health are

taken. What are the physiological effects of the training for and the participation in such efforts?

The contribution of the physiologist to the answer to this question must be limited to a statement of what is known of the physiological conditions during strain. It is for the clinician to tell us how far these dangers actually produce ill effects; and the clinical evidence, to be at all satisfactory, must be drawn, not simply from the study of cases which apply for treatment, but from a systematic study of an entire group of *average* people participating in such work. For it must be remembered that the appeal of athletics is not simply to those who will finally make a school or college team, but to a much larger proportion of the student body.

First, I think we should make sure that we appreciate the weight of the burden of physiological adjustment which muscular activity places upon the organism, for this is always greater than is generally supposed. It may be measured with a fair degree of accuracy by the respiratory exchange, since this varies almost *pari passu* with the work. The comparison must, however, be made between the expired air, collected directly from the respiratory passages, during rest and during the actual performance of work. Measurements made in respiration chambers, unless the work extends over several hours (and very severe work can not be maintained continuously for this length of time), necessarily involve some lag in the collection of the samples. I will quote from two reliable observations involving such direct analyses of the expired air.

Leo Zuntz[3] found that the oxygen consumed per minute while riding a bicycle on a level asphalt track at a speed of nine miles an hour increased from 263 c.cm. (during rest) to 1,550 c.cm., and that when the speed was increased to thirteen miles an hour it rose to 2,058 c.cm., an increase of eightfold. This corresponds very closely with what Zuntz and Lehmann[4] had previously found for the horse, where the oxygen consumed and the carbon dioxide excreted per minute increased from five to ten fold with moderately heavy to hard work, respectively. All observations, moreover, show that this respiratory need must be met at once, which means an enormous increase of work on the part of the respiratory and vascular systems. When we find the muscular work of the sitting posture almost doubling that of the sleeping condition; even light activity doubling the work of the sitting posture; only moderately heavy work increasing it four or five fold, while vigorous activity increases it eight and ten fold; and when we reflect that all this must be immediately provided for in the successful readjustment of the circulation and respiration—we begin to appreciate the possibilities of physical strain.

Two very different forms of muscular activity introduce into the organism conditions of strain and the nature of the strain in the two cases is very different; first, when a supreme effort is put forth suddenly and for comparatively brief periods of time, as in the hundred yards' dash; and, second, where vigorous but less violent exertion is prolonged over a much greater time, as in long-distance running. Probably the chief dangers in the two cases are, respectively, excessive arterial pressure, at times combined with disturbance of the pumping action of the heart, and fatigue.

With regard to arterial pressure during muscular activity, the reliable data at hand are sufficient to give us an idea of

[3] Leo Zuntz, "Untersuchungen über den Gaswechsel und Energieumsatz des Radfahrers."

[4] Zuntz and Lehmann, "Stoffwechsel des Pferdes," Berlin, 1889.

the possible strain which may at times be placed upon the heart and arteries, but they do not give us the knowledge we should have of the pressure conditions during fatigue. It is clear enough that in the increased output from the heart and the probable constriction of the arterioles of the splanchnic and other internal organs pressor factors are introduced, while in the dilation of muscular and cutaneous arterioles depressor factors are introduced; through the changes of thoracic aspiration and the rhythmic pressures on the bloodvessels of the working muscle and moving joints, arterial pressure must also be influenced, the exact direction of the influence probably differing with the nature of the exercise and the condition of the organism. Finally, where very rapid rhythmic or sustained contractions are made, the blocking of the circulation through the muscles must exert a marked depressor influence. The net result must be the algebraic sum of these pressor and depressor influences and we are prepared to find, as we actually do, considerable variations of result. Thus Zuntz and Hagemann[5] found in the horse a slight fall of mean pressure, but sometimes a slight rise with moderate work. In the dog, on the other hand, Tangl and Zuntz[6] always found a rise of from 20 to 30 mm. of mercury with active exercise; but when the dog was made to run very rapidly in the treadmill so that distinctly labored breathing developed, enormously high mean pressures of 275 mm. of mercury were recorded. In the latter case, the relaxation period of the muscle was probably not long enough to permit the blood to flow through in any quantity, so that the great muscular outlet from the aorta was temporarily blocked off. These direct measurements, however, suffice to show that moderate muscular activity causes only a slight change of mean arterial pressure and that change usually an increase of from 20 to 30 millimeters of mercury; but that certain forms of muscular activity may result in pressures which must be looked upon as distinctly dangerous.

Upon man I would next call attention to Bowen's[7] very careful measurements of systolic pressure, during work on a stationary bicycle, the work being described as "just vigorous enough to satisfy the needs of a healthy man who is not in training for athletics." He found that the systolic pressure rose from 130 mm. of mercury to a maximum of 180 mm. within the first five or ten minutes; after this there was a fall to a plateau of 165 or 170 mm., or even a continuous but gradual fall throughout the thirty-five minutes of the work. After the cessation of the work there was a sudden fall to or even below the normal, followed by a return to normal within ten minutes. Those interested in the subject will find Bowen's paper very suggestive.

Lastly I should mention McCurdy's[8] measurements of systolic pressure during the maximal effort of the ordinary gymnasium test of strength of legs. The pressure was first raised in the brachial armlet to 500 mm. of mercury, or thereabouts, and then rapidly lowered during the effort until the radial pulse could be felt. This method would give somewhat low records for systolic brachial pressure, but even then pressures of from 175 to 265 mm. of mercury were recorded. The form of effort reproduced the conditions of

[5] Zuntz and Hagemann, "Stoffwechsel des Pferdes," 387 foll, Berlin, 1898.

[6] Tangl and Zuntz, *Pflüger's Archiv*, LXX., 554, 1898.

[7] Bowen, *American Journal of Physiology*, XI., 59, 1904.

[8] McCurdy, *American Journal of Physiology*, V., 95, 1901.

forced expiration with closed glottis and it was found that this act alone (without the lifting) caused a similar rise. I can confirm this statement from experiments made in my own laboratory.

These facts are enough to show the extent to which certain forms of muscular activity may raise arterial pressure and we can not but regard this condition, even in the young, as a source of danger. The risk of cardiac dilatation, valvular insufficiency and injury to the arterial wall have been frequently pointed out, and it does not seem that the need for the utmost caution is put aside by the argument that investigation fails to show bad effects on health among those who have engaged in athletic contests in the past. Meylan's[9] very careful and satisfactory study of the Harvard oarsmen from 1852 to 1892, inclusive, undoubtedly shows marked freedom of these men from cardiac or other vascular troubles in later life, and force the conclusion that this most vigorous of athletic trainings is consistent with the subsequent good health of those who "make the crews." But these are the picked men, physically, of the university and the facts only show that with proper training and under proper medical supervision these picked men may engage in such work without harmful after-effects. But it is one thing to supply adequate medical supervision to a team or crew, and quite a different thing to supply it to a large student body engaging in athletic training; for no medical supervision can be regarded as adequate unless it detects the signs of mischief before it has gone beyond the possibility of repair. In the absence of such supervision it is simply common every-day prudence to keep physical effort well within the bounds of safety. The best gymnasium instructors watch carefully for signs of strain, such as skin pallor, labored breathing and the like, during a run and diminish at once the intensity of the work. And in doing so they are only putting into practise the hygienic principle which we have already drawn from the consideration of the probable extent of adaptation of the race as a whole to muscular activity. The average man or woman, the average boy or girl, is not adapted for extreme effort, and it is not proved by experiment or experience that, in such cases, training can supply what heredity has failed to furnish.

Passing to the second condition of strain imposed upon the organism by athletic activities, that of vigorous but not supreme effort continued over longer periods of time, I shall cite only the observations[10] made for three years upon contestants in the Marathon Race held annually under the auspices of the Boston Athletic Association. These show that at the close of the twenty-four mile race (two and one half to three hours) there was always an enlargement of the heart with a systolic murmur (which, however, Larrabee hesitates to attribute to mitral incompetence), that all the signs pointed toward lowered mean blood-pressure; that the blood counts showed "a leucocytosis corresponding in intensity and type with that observed in various inflammatory diseases"; and that the urine invariably contained traces of albumin and more or less blood.

This presents to us the picture of the organism struggling with the conditions of marked general fatigue, especially in the working of the heart and of the vasomotor mechanism. The circulation is being maintained under extremely unfavorable conditions and presents every sign of venous congestion with its resulting inter-

[9] Meylan, "Harvard University Oarsmen," *Harvard Graduates' Magazine* and *American Physical Education Review*, March and June, 1904.

[10] Blake, Larrabee and others, *Boston Medical and Surgical Journal*, CLXVIII., 195, 1903.

ference in the work of the kidneys. It should also be pointed out that even though arterial pressure is subnormal, yet a weakened heart working against comparatively low pressure may be in as great danger as a strong and fresh heart working against high pressure. The conditions may, it is true, be only transitory; they may pass away without lasting ill effects; but they are all distinctly unfavorable conditions in the organism, and we are not justified in looking upon them as other than warnings which must be heeded in formulating proper systems of physical training for the masses.

It is, of course, easy to exaggerate these dangers and it is difficult even to state them clearly and fairly without running the risk of being misunderstood. I should be the last man in the world to advocate the banishment of athletic activities from college life. I would not be understood to discourage new forms of physical exercise merely because they are new and have not formed part of the ancestral activities to which the adaptation of the organism is most perfect. I believe in the active life, in the cultivation of greater physical strength and endurance with all classes and all ages; but let us do this with full understanding of the risks involved, always with due reference to securing in each individual the maximal efficiency in subsequent life, and above all with the determination to provide for the masses the best possible physical training.

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CURRENT PROGRESS IN CONSERVATION WORK

The Proceedings of the Conference of Governors on the conservation of the natural resources of the country, held in the White House, Washington, May 13–15, 1908, have just been issued in a volume of xxxv + 451 pages. The bulk of the edition is distributed by senators and representatives; the smaller portion designed for distribution by the President among the governors and other conferees is in course of distribution under the direction of ex-President Roosevelt by the Joint Committee on Conservation (Hon. Gifford Pinchot, chairman).

The National Conservation Commission, appointed by the President on June 8 last pursuant to action at the Governors' Conference, held a working session during the first week in December last, at which an inventory of the resources of the country was discussed and a report adopted; during the second week in December the inventory and report were considered at the Joint Conference of State and National commissions and commissions or committees appointed by national organizations. The Joint Conference approved and supplemented the papers, which were duly submitted to the President and were by him in January transmitted to Congress with an approving message. The inventory is the most complete quantitative statement of natural resources ever prepared for any country. After some delay, publication was authorized by Congress, and the matter is now in type and undergoing proof revision. It will form two volumes, aggregating some 1,700 pages. Provision has not yet been made for adequate distribution.

The complete preliminary Report of the Inland Waterways Commission (which body arranged for the Governors' Conference and the subsequent steps in the conservation movement) has been in the hands of the printer for several months, completion being delayed by extensive proof revision, especially of the extended statistical matter prepared in the office of Hon. Herbert Knox Smith, Commissioner of Corporations. The matter is now on